Egypt. J. Chem. **Vol. 62,** No. 8, pp. 1413 - 1418 (2019)

Egyptian Journal of Chemistry
http://ejchem.journals.ekb.eg/

Shear Properties of Apparel Fabrics Using Different Spun Yarns

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THE SHEAR properties of a fabric determine its performance properties as well as the appearances where it is subjected to a wide variety of complex deformations during usage as apparel. In this paper, woven fabrics have been made of cotton spun yarns with three different spinning techniques (ring spun, open-end spun and compact ring spun yarns) in weft direction. Some twill based weave structures were manufactured on the weaving machine with varying the weft density level. The Kawabata Evaluation System was used to measure the shear properties; shear rigidity, shear hysteresis at 0.5 deg.shear angle and shear hysteresis at 5 deg. shear angle. A statistical analysis was performed to get the effect of decided parameters on shear. A highly significant effect of the weave structures and weft density on the measured shear properties were found, while the type of weft yarns has insignificant effect. A multiple linear regression equations were derived to get a mathematical relationship between the influencing parameters; (the float length, yarn diameter, and weft density) and the shear properties. The derived regression equations had high correlation coefficients values.

Keywords: Woven fabric, Shear angle, Spinningtechniques, Weave structure, Apparel fabrics, Kawabata Evaluation System, Regression analysis.

Introduction

The shear behavior of a fabric determines its performance properties when subjected to a wide variety of complex deformations in use. The ability of a fabric to be deformed by shearing distinguishes it from other thin sheet materials such as paper or plastic films. Jurgita and Eugenija[1] stated that this property enables fabric to undergo complex deformations and to conform to the shape of the body. They added that shearing influences draping, flexibility and also the handle of woven fabric. Shear properties are important not only for fabrics and/or clothing but for textile composites as well. Lo and Hu [2] stated that shear properties of woven fabrics are important in many applications the understanding of fabric shear behavior were introduced by many early trials of measuring it. Dreby [3], Go et al[4], Mornerand Eeg-Olofsson [5], and Kawabata [6, 7] each introduced a shear apparatus to measure fabric shear properties.

Fabric Objective measurements

Cusick [8], Lindberg et al. and Grosberg and Park [9] used a qualitative method to describe shear properties with a model which are based on the concept of Low-Stress Mechanical Properties of Fabrics. They indicated that the hysteresis produced during shearing is determined wholly by the frictional restraints arising in the rotation of the yams from the intersecting points in the fabric.

Fabric Hand, Drape, and Appearance

Many literature proves that the shear mechanism is one of the important properties influencing the draping, pliability, and handle of woven fabrics [6, 7, 11]. Shear deformation of woven fabrics also affects their bending and tensile properties in various directions other than just the warp and weft directions [3, 9, 12].

In addition some literature [12,13] have shown that shear rigidity can be calculated from the tensile properties of a fabric in bias (45deg) direction based on the interrelations of the in plane

*Corresponding author e-mail: mezzat2012@gmail.com
Received 26/12/2018; Accepted 24/2/2019
DOI: 10.21608/ejchem.2019.6875.1577
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properties of a plate. The uniaxial tension of a bias-cut fabric specimen is relatively simple and may be carried out on any extensometer. This method of fabric properties investigation is therefore the most appropriate for industrial use. However, when this test is applied to fabric, shearing is non-uniform throughout the specimen due to the distortion of width uniformity. Shear angle is one of the main criteria for characterizing the formability of fabrics. As the fabric is fitted onto a superficial surface, shearing occurs incrementally until the critical shearing angle is reached. When this angle exceeds a strict value, the specimen starts to buckle. wrinkling is observed.

Objectives of this article are Studying the effect of the weave structure, type of weft yarn spinning and weft density on the shear properties measured on Kawabata Evaluation System; KES-F (shear rigidity, shear hysteresis at 0.5 deg. shear angle and shear hysteresis at 5 deg. shear angle). In addition to deriving a mathematical relationship between the influencing parameters; (the float length, yarn diameter, and weft density) and the measured shear properties, to be used as reliable predictive models.

Experimental

Fabric samples:

The weaving machine: Rapier Vamatex HS, Italy

Three weave structures (shown in Table 1)

Warp yarns:

Ring spun (Giza 86 cotton), count Ne 40/1

Weft yarns:

Compact spun (Giza 86 cotton), Ne 40/1
Ring spun (Giza 86 cotton), count Ne 40/1
OE spun (Giza 86 cotton), count Ne 40/1

Weft densities:

36, 42, and 50 picks per cm

Warp density:

42 picks per cm

Fabric shear measurements:

The KES-F system:
The Tensile and Shear module
Sukuagira Lab;
Kyoto institute of technology,
Kyoto, Japan

Fig. 1. Kawabata Evaluation; systemKES-F (Tensile and Shear).

Results and Discussion

The KES shear measurements

The measured shear properties G, 2HG, and 2HG5 of the fabrics under study are shown in Table 1. The 27 fabric samples contain 3 weave structures, 3 weft spun yarns, and 3 weft densities.

To achieve the objective of deriving mathematical reliable predictive models some calculations and measurements are developed to characterize both weave structures and weft spun yarns numerically.

Fabric float length

The average float length of the 3 fabric structures are calculated according to the following equation:

Fabric float length; ***AFL***=
*(no. of threads per repeat/ no. of intersections per repeat)*F*

Where; F constant based on original weave type (for twill weave; F=0.39)

TABLE 1. Fabric shear measurements on KES-F (Tensile and Shear).

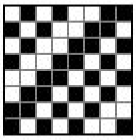
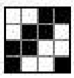
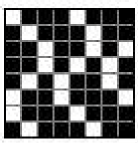
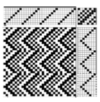
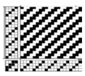
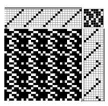
Fabric Code	Design	Spinning system	Weft/cm	Shear rigidity; G (gf/cm)	Shear hysteresis; 2HG (gf/cm)	Shear hysteresis; 2HG5 (gf/cm)
D111		Compact yarn	**36.0**	2.044	1.391	6.700
D112			**42.0**	2.655	2.179	9.082
D113			**50.0**	3.154	2.345	8.823
D121		Ring yarn	**36.0**	2.327	2.556	8.610
D122			**42.0**	2.301	2.594	7.984
D123			**50.0**	3.862	2.410	9.432
D131		OE yarn	**36.0**	2.445	2.574	8.946
D132			**42.0**	3.266	3.158	10.928
D133			**50.0**	3.022	2.762	9.114
D211		Compact yarn	**36.0**	2.270	2.183	6.855
D212			**42.0**	1.916	1.944	6.077
D213			**50.0**	1.934	2.225	5.835
D221		Ring yarn	**36.0**	1.131	1.312	3.948
D222			**42.0**	1.575	1.515	5.543
D223			**50.0**	2.427	2.276	8.319
D231		OE yarn	**36.0**	1.162	1.391	4.071
D232			**42.0**	1.901	1.509	5.103
D233			**50.0**	2.478	2.056	8.157
D311		Compact yarn	**36.0**	0.572	1.117	2.505
D312			**42.0**	0.867	1.365	3.758
D313			**50.0**	0.931	1.497	4.072
D321		Ring yarn	**36.0**	0.718	1.303	3.117
D322			**42.0**	1.013	1.487	4.378
D323			**50.0**	1.311	1.709	5.610
D331		OE yarn	**36.0**	0.591	1.308	2.932
D332			**42.0**	0.739	1.579	2.983
D333			**50.0**	1.595	1.859	6.430

TABLE 2. The average float length of the 3 fabric structures.

Design Code	Weave structure	AFL
D1		1.1
D2		1.3
D3		1.5

Yarn diameters:

The selected spun yarns used for weft insertion had different yarn diameters;

Ring spun yarn:	0.19mm
Compact spun yarn:	0.17mm
OE spun yarn	0.21mm

Regression analysis

To perform regression analysis, 3 predictors are used:

X1: average float length AFL
X2: yarn dia (mm)
X3: weft density/cm

The response is the KES shear properties measured

The multiple linear regression model was performed and coefficient of correlation was calculated to check the linearity of the relationship

Shear rigidity; G (gf/cm)

The following table summarizes the Regression Statistics of Shear rigidity; G

TABLE 3. Regression Statistics of Shear rigidity; G.

Regression Statistics	
Multiple R	0.940460906
R Square	0.884466716

	Coefficients	*P-value*
Intercept	4.921121584	5.86E-05
X1	-4.65009722	1.88E-11
X2	2.378777778	0.542142
X3	0.059333168	1.65E-05

From the previous table it could be concluded that linear regression model is acceptable for predicting Shear rigidity; G as coefficient of correlation R=0.94.

Both x1 and x3 have significant effect on G (p-value=1.88E-11 and1.65E-05 resp.), while insignificant effect is found by x2 (p-value=0.542142.) which may indicate that the yarn diameters are close to each other.

Shear hysteresis at 0.5 deg. shear angle; 2HG (gf/cm)

The following table summarizes the Regression Statistics of Shear hysteresis; 2HG

TABLE 4. Regression Statistics of Shear hysteresis; 2HG

Regression Statistics	
Multiple R	0.82593273
R Square	0.682164875

	Coefficients	*P-value*
Intercept	2.700397898	0.01362
X1	-2.42941667	2.14E-06
X2	5.413611111	0.175731
X3	0.031416907	0.00912

From the previous table it could be concluded that linear regression model is acceptable for predicting Shear hysteresis; 2HGas coefficient of correlation R=0.83.

Both x1 and x3 have significant effect on G (p-value=2.14E-06 and 0.00912 resp.), while insignificant effect is found by x2 (p-value=0.175731.) .

Shear hysteresis at 5 deg. shear angle; (gf/cm)

The following table summarizes the Regression Statistics of Shear hysteresis; 2HG5

TABLE 5. Regression Statistics of Shear hysteresis; 2HG5.

Regression Statistics	
Multiple R	0.912861862
R Square	0.833316779

	Coefficients	*P-value*
Intercept	13.36515818	0.00039
X1	-12.1761667	1.01E-09
X2	13.76694444	0.276666
X3	0.143413589	0.000465

From the previous table it could be concluded that linear regression model is acceptable for predicting Shear hysteresis; 2HGas coefficient of correlation R=0.91.

Both x1 and x3 have significant effect on G (p-value=1.01E-09 and 0.000465 resp.), while insignificant effect is found by x2 (p-value=0.276666).

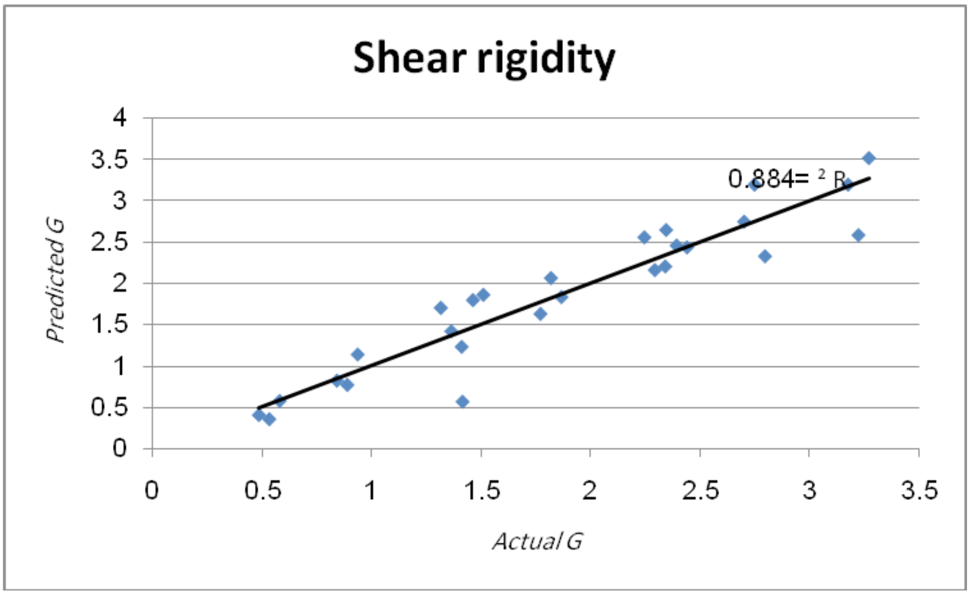


Fig. 2. Predicted shear rigidity vs actual shear rigidity.

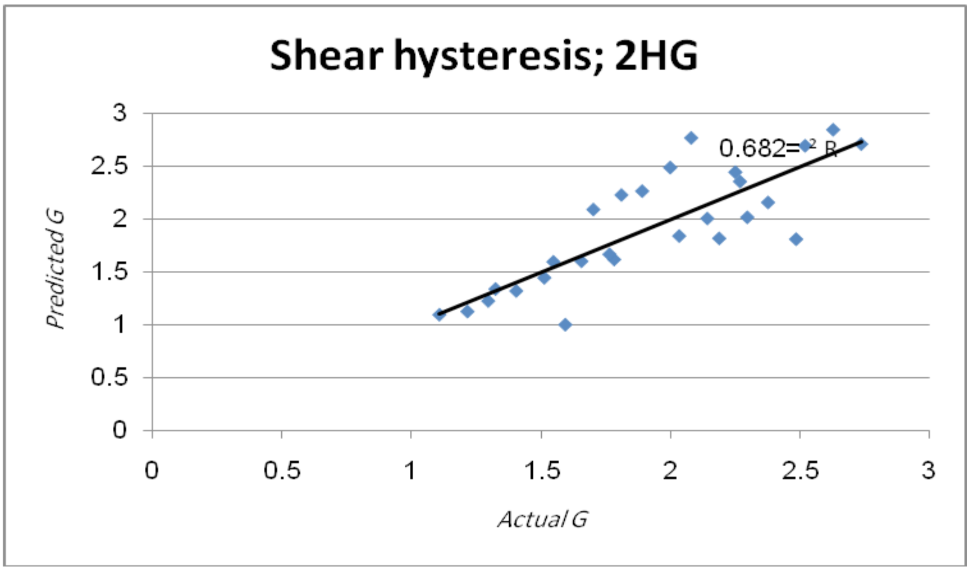


Fig. 3. Predicted shear hysteresis 2HGvs actual hysteresis 2HG.

Conclusion

The shear properties of apparel fabrics need to be measured and predicted accurately by both the fabric and clothing manufacturers for expecting its performance, hand, drape, and appearance. Shear properties executed by KES-F system can be easily mathematically predicted accurately using liner and/or nonlinear regression models from simple measurements for the fabric float length, density, and yarn diameter.

The fabric hand and drape have a direct relationship with the KES shear measurements. More efforts are needed from researchers and product developers to facilitate shear characteristics by simpler and reasonable ways.

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دراسه خصائص القص لاقمشه الملابس باستخدام خيوط مغزوله مختلفه

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تحدد خصائص اجهاد القص للقماش المنسوج خصائص أدائه وكذلك مظهريته. حيث يتعرض فيها لمجموعة واسعة من التشوهات المعقدة أثناء الاستخدام كملابس. في هذ البحث ، تم صنع أقمشة منسوجة من خيوط نسجيه قطن ومغزوله بثلاثة أساليب مختلفة للغزل (غزل حلقى ، غزل طرف مفتوح وغزل مدمج) في اتجاه اللحمة. تم تصنيع بعض التراكيب النسجيه المستندة إلى نسيج مبردى على ماكينه النسيج مع تغيير مستوى كثافة اللحمة. تم استخدام نظام تقييم كواباتا لقياس خصائص القص. وهى صلابة القص ، هستريسس القص (قدره القماش على تحمل اجهاد القص) عند زاوية قص 0.5 درجة. وهستريسس القص عند زاوية قص 5 درجة. تم إجراء تحليل إحصائي للحصول على تأثير العوامل المحددة على القص. وجد ان هناك تأثير كبير للغاية للتركيب النسجي وكثافة اللحمة على خصائص القص المقاسة ، في حين أن نوع خيوط اللحمة له تأثير ضئيل. تم استنتاج معادلات انحدار خطية متعددة للحصول على علاقة رياضية بين العوامل المؤثرة ؛ (طول التشييف ، قطر الخيط ، وكثافة اللحمة) وخصائص القص المقاسه. كان لمعادلات الانحدار المشتقة قيم معاملات ارتباط عالية.